Run II PMG
Stacking Rapid Response Team Report

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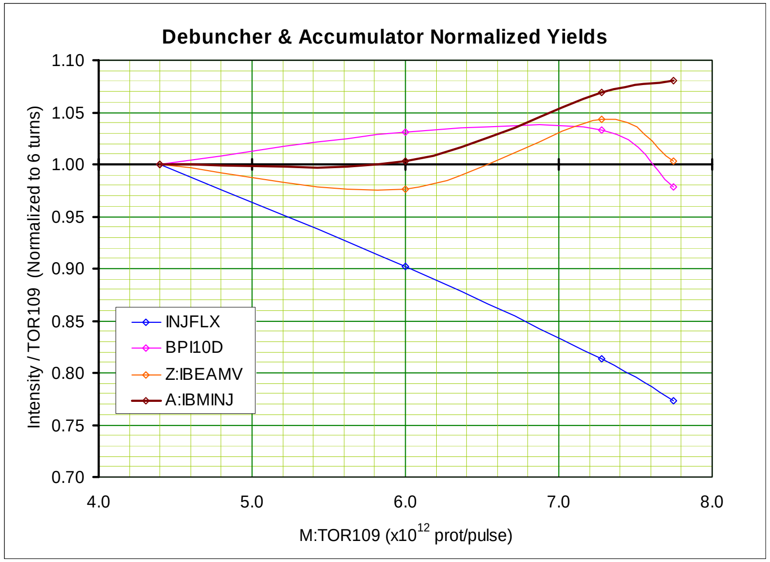
January Antiproton Study Period

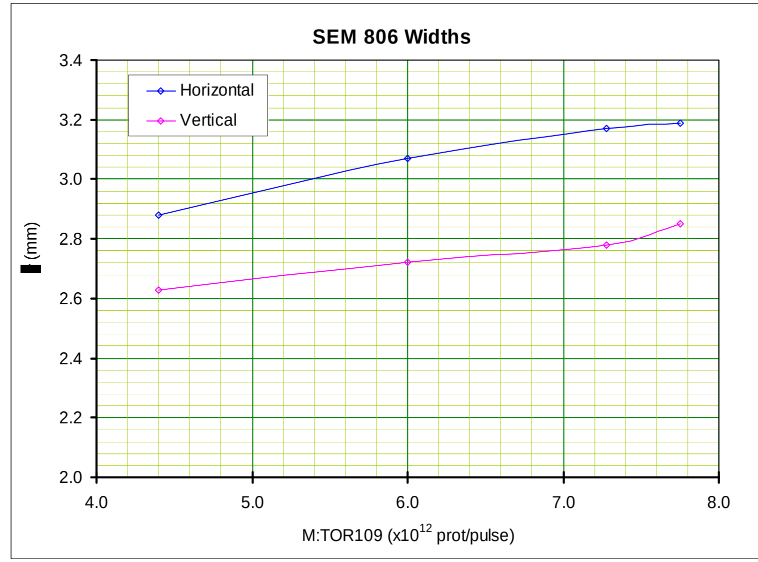
- Quad Steering of the AP1 line
  - Not finished
- Alignment of the Debuncher horizontal orbit and moveable devices.
  - Did not do arcs
  - Need to Energy align the AP2-Debuncher-Accumualtor
  - Horizontal Aperture up to 35π-mm-mrad!!!
- Installation and commissioning of Debuncher lattice modifications
  - First round done
  - Vertical aperture up to 34π-mm-mrad
- Removal of the Debuncher Schottkies
  - Completed
- Obstruction search of the AP2 line.
  - Completed – none found
- Installation of 4 additional AP2 trims
  - Two trims installed
  - Two trims staged
- D/A Beam based alignment
  - Completed to the Q3-Q6 straight section
- Accumulator orbit and aperture optimization
  - Underway
  - Backed out of orbit changes
    - Need to update quad centering software
    - Need to de-bug running wave software
  - Will only complete moveable devices

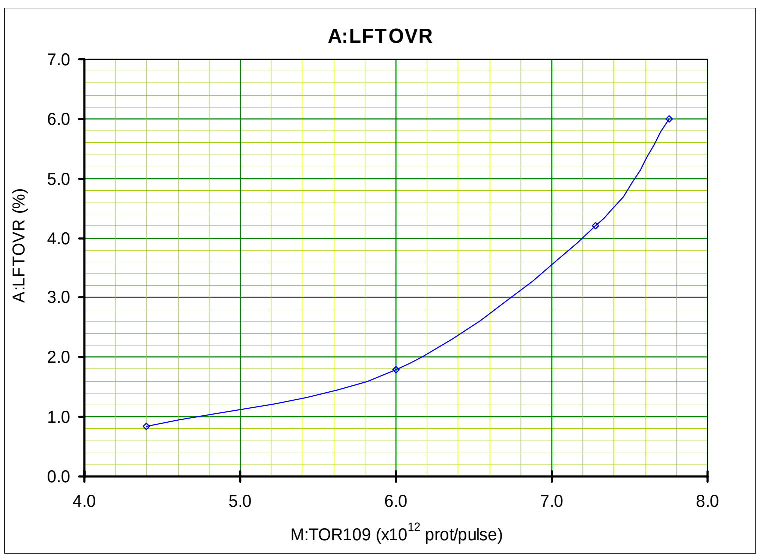
Returning to Stacking After the Studies

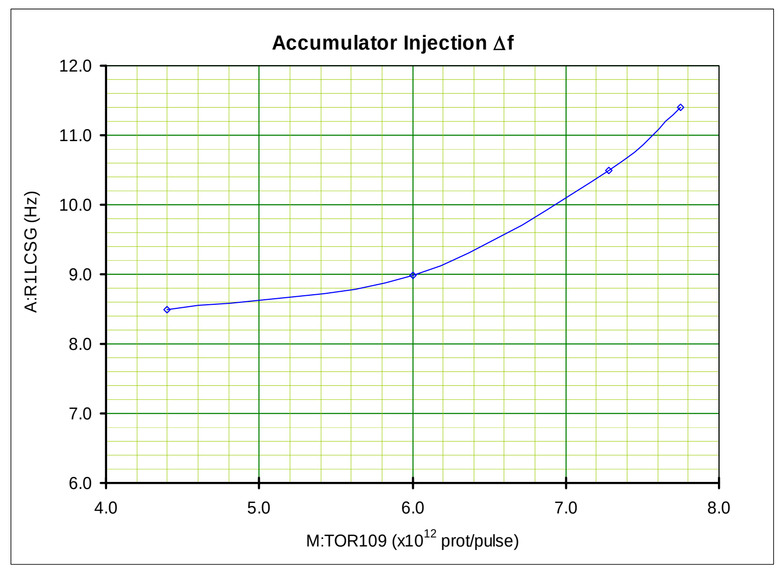
- Production into the Debuncher was good
- Overall production was a function of the amount of beam on target.
- Possible explanations
  - Spot size on target vs proton intensity
  - Bunch length on target vs proton intensity
  - Debuncher transverse cooling
    - Far away from optimum gain
    - Not tripping TWT's
  - Accumulator Stacktail Flux
- Measure production at various places along the chain as a function of intensity on target

Antiproton Flux vs Intensity on Target









Antiproton Stacking - Stacktail System

- The time evolution of the antiproton phase space during cooling is best described by the Fokker-Plank Equation

$$\frac{\partial \psi}{\partial t} = -\frac{\partial \phi}{\partial E}$$

$$\phi_c = \frac{\Delta E_c}{T_o}\psi = eV_o f_o \psi \sum_n \mathrm{Re}\{G_n(E)\}$$

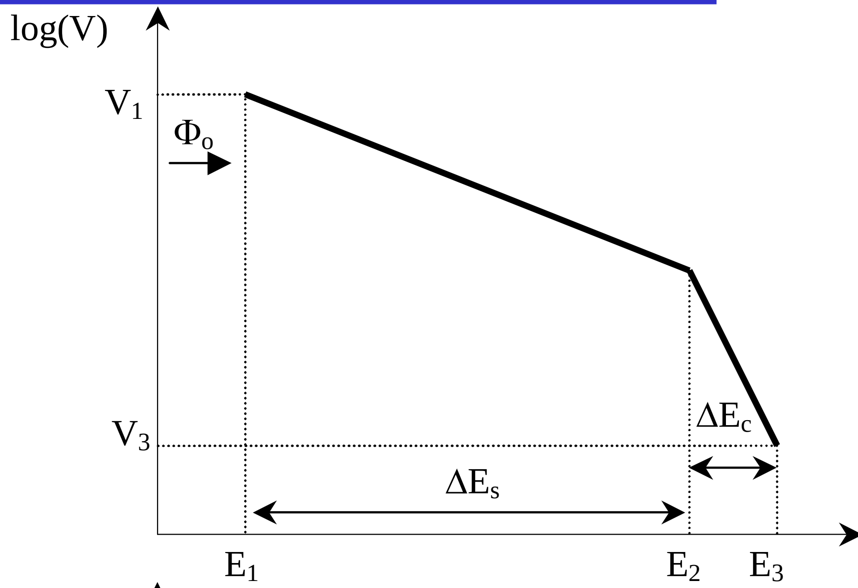
$$\phi_h = \frac{1}{2}\frac{\Delta E_h^{\ 2}}{T_o}\frac{\partial \psi}{\partial E} = \frac{1}{4}(eV_o f_o)^2 \frac{E_o}{\eta f_o}\psi \frac{\partial \psi}{\partial E}\sum_n |G_n(E)|^2$$

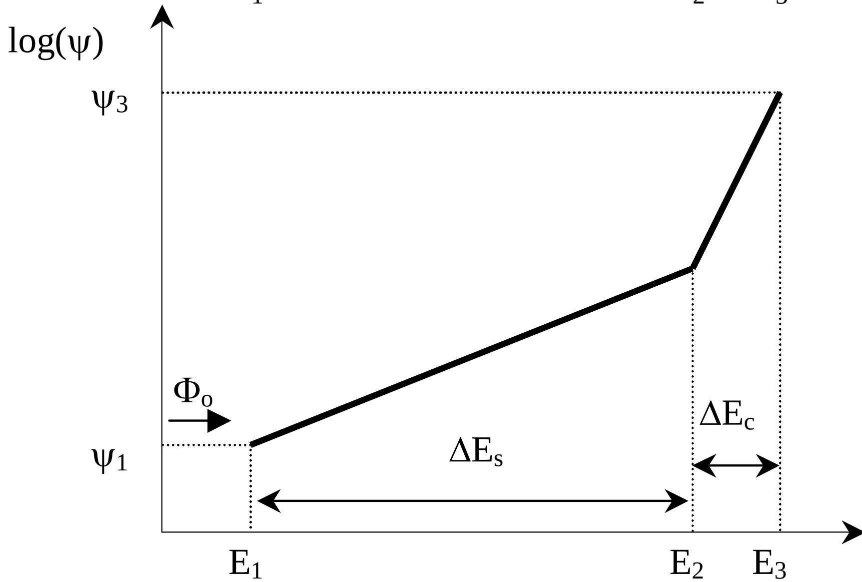
- Optimum profile that maximizes $d\psi/dE$ for a constant stacking rate is exponential

$$G_n(E) = g_o e^{-E/E_d} \qquad \psi(E) = \psi_o e^{E/E_d}$$

$$\psi_o = \frac{N_T P_D}{\Delta E_{bD}}$$

$$\boxed{\phi_m = \eta f_o \frac{E_d}{E_o}\frac{\left(W/f_o\right)^2}{\ln\left(f_{max}/f_{min}\right)}}$$





Antiproton Stacking – Stacktail System

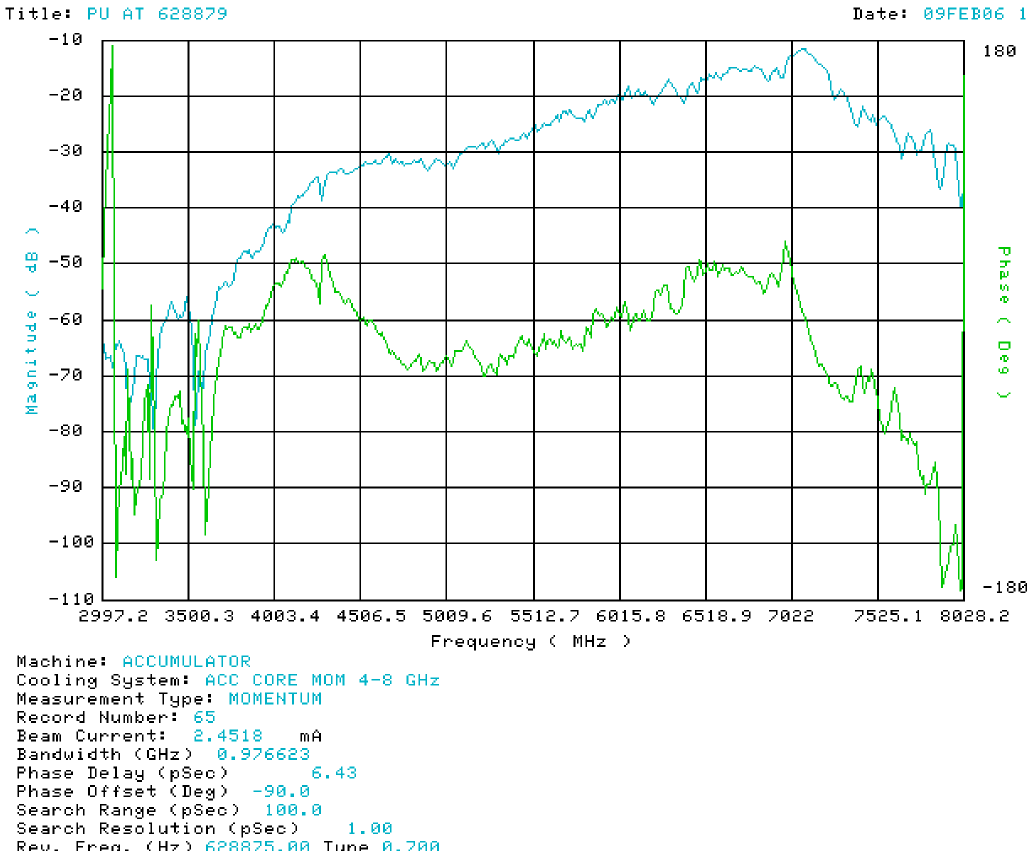
- The measured Accumulator 2-4 GHz Stacktail system can support a flux of 30mA/hr.
- The currently used 2-4 GHz core momentum system is the same frequency as the Stacktail system
  - At a flux of 15mA/hr, the core 2-4 GHz system can support a exponential gain slope that is a factor of two larger than the gain slope of the Stacktail.
  - As the number of particles in the core increases, the factor of 2 gain slope is exceeded and the core pushes back on the Stacktail and the flux must be reduced.
- For large fluxes into the Stacktail, the 2-4 GHz core momentum system cannot support a core.

Antiproton Stacking – Stacktail System and the Core 4-8 GHz System

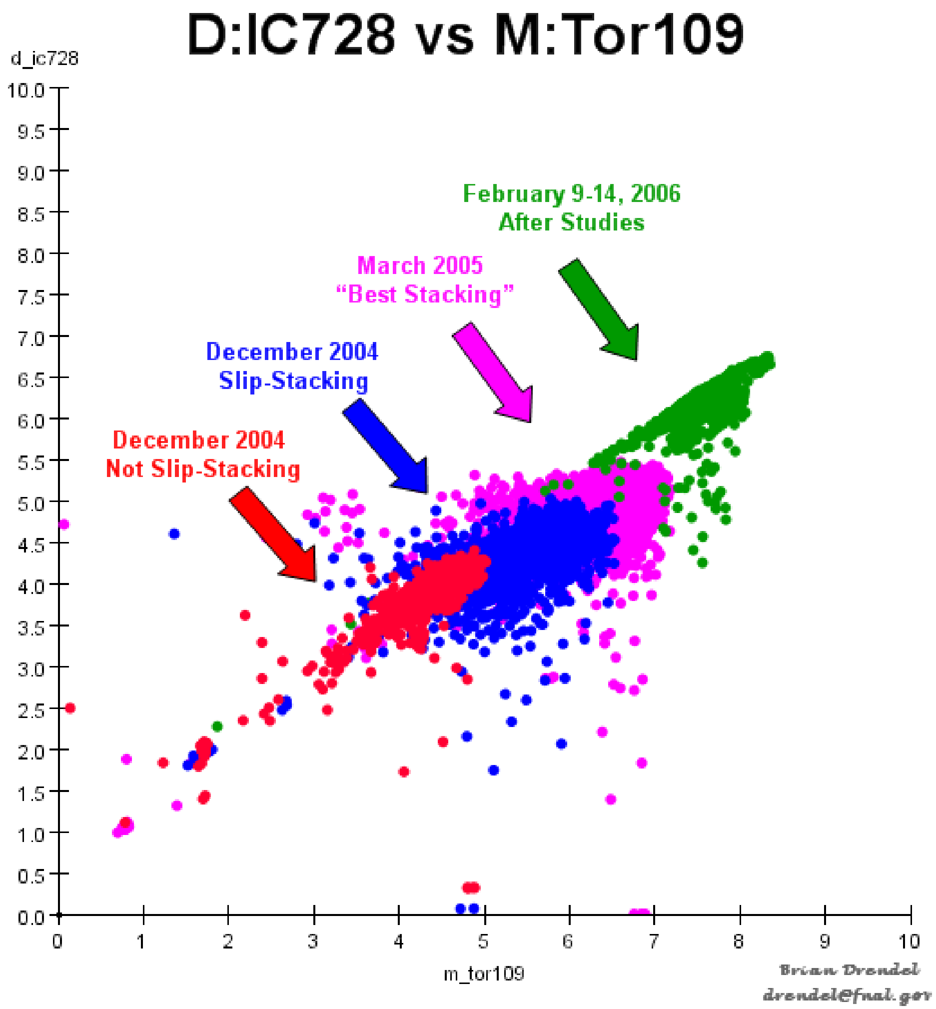
- To support a core at high flux, the 4-8 GHz core momentum system must be used.
- Because the 4-8 GHz core system runs at twice the frequency, the electrodes are ½ the size so the system has a factor of two smaller momentum reach.
- Moving the core closer to Stacktail to accommodate the smaller reach resulted in system instabilities at moderate stacks.
- We now :
  - Use the 2-4 GHz core momentum system to augment the hand-off between the Stacktail and the 4-8 GHz core momentum system
  - Run the 4-8 GHz core momentum system at MUCH larger gain.
  - Run the Stacktail during deposition debunching to pre-form the distribution to match the Stacktail profile

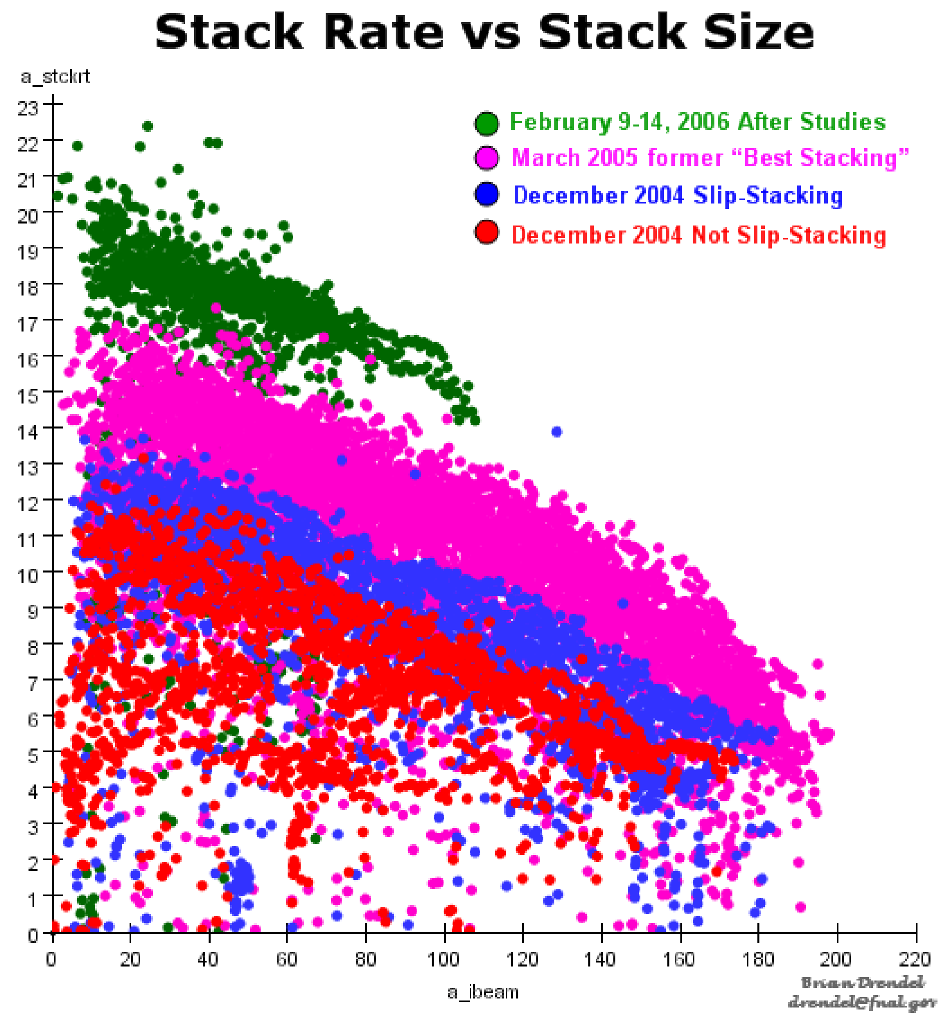
Core 4-8 GHz Momentum Cooling System bandwidth

- 1 GHz of bandwidth at 7 GHz is ~3x more powerful than 1 GHz of bandwidth at 2.5 GHz
- With simple redesign of the system equalizers, the 4-8 GHz system will be 5.7x more powerful than the 2-4 GHz system



Stacking Performance





Antiproton Parameters

	Antiproton Parameters						
Phase	1	2	3	4	5	6	
Zero Stack Stacking Rate	13.0	16.0	18.9	30.2	30.2	30.2	x10^{10}/hour
	13.0	16.0	16.6	25.2	25.2	25.2	
	13.0	16.0	16.6	20.2	20.2	20.2	
	13.0	16.0	16.0	16.0	16.0	16.0	
Average Stacking Rate	6.3	7.4	9.6	21.7	21.7	21.7	x10^{10}/hour
	6.3	7.4	8.5	14.8	17.4	17.4	
	6.3	7.4	8.5	11.3	11.3	13.3	
	6.3	7.4	8.3	8.3	8.3	9.7	
Stack Size transferred	158.2	163.8	211.5	476.5	476.5	476.5	x10^{10}
	158.2	163.8	187.9	324.7	382.5	382.5	
	158.2	163.8	187.9	248.6	248.6	293.5	
	158.2	163.8	181.5	181.5	181.5	214.5	
Stack to Low Beta	117.1	124.5	169.2	381.2	381.2	381.2	x10^{10}
	117.1	124.5	144.7	253.3	298.3	298.3	
	117.1	124.5	144.7	191.4	191.4	226.0	
	117.1	124.5	138.0	138.0	138.0	163.0	
Pbar Production	16.0	15.0	16.0	21.0	21.0	21.0	x10^{-6}
	16.0	15.0	15.0	17.5	17.5	17.5	
	16.0	15.0	15.0	16.0	16.0	16.0	
	16.0	15.0	15.0	15.0	15.0	15.0	
	FY04 Plan	**Slip Stacking**	**Recycler Ecool**	**Stacktail**	**Helix**	**Reliability**	

Future Pbar Work

- Lithium Lens (0 – 25%)
  - Lens Gradient from 760T/m to 1000 T/m
- Slip Stacking (7%)
  - Currently at 7.5×10^{12} on average
  - Design 8.0×10^{12} on average
- AP2 Line (5-30%)
  - Lens Steering
  - AP2 Steer to apertures
  - AP2 Lattice
- Debuncher Aperture (13%)
  - Currently at 30-32um
  - Design to 35um
- DRF1 Voltage (5%)
  - Currently running on old tubes at 4.0 MEV
  - Need to be a t 5.3 MeV
- Accumulator & D/A Aperture (20%)
  - Currently at 2.4 sec
  - Design to 2.0 sec
- Stacktail Efficiency
  - Can improve core 4-8 GHz bandwidth by a factor of 2
- Timeline Effects
  - SY120 eats 7% of the timeline

Proposed Pbar Studies Review

- Operational Issues (Drendel & Johnson)
  - Setup one-shots for circ beam in Deb
  - Setup Deb partial turn beam up AP2
  - Setup AP2 extraction of Deb circ beam
  - Setup for D/A orbit studies
- Debuncher Orbit
  - Deb Orbit/BPM-Quad offset determination (Gollwitzer)
  - Deb Orbit Correction(Gollwitzer)
  - Deb Component Centering (Werkema)
  - Deb Electrical Centering (Gollwitzer)
  - Deb Lattice Measurements (Nagaslaev)
- AP2
  - Setting of the AP2-Deb Injection Region (McGinnis)
  - AP2 and Deb survey (Harms)
  - Lattice Design (Lebedev)
  - AP2 Orbit/BPM-Quad offset determination (Gollwitzer)
  - AP2 Orbit Correction (Gollwitzer)
  - AP2 Lattice Measurements (Nagaslaev)

Proposed Pbar Studies Review

- D/A Line
  - Acc Injection region (kicker & septa) (Derwent)
  - D/A Beam Based Alignment (Derwent)
  - Acc Injection channel and orbit Apertures (Derwent)
  - Deb Reverse Proton TBT system (Vander Meulen)
  - D/A Kicker time during stacking (Ashmanskas)
  - DRF2 timing (Ashmanskas)
- Accumulator Aperture
  - Quad centers on the Accumulator (Werkema)
  - Orbit Correction in the Accumulator (McGinnis)
  - Moveable devices (Werkema)
- Stacking
  - P1-P2-AP1 drift and auto-tune (McGinnis)
  - AP2 Orbit drift and correction (McGinnis)
  - Stacking Losses in AP50 (Werkema)